Final Report

Movements and Survival of Raccoons Translocated from the Suburban Environment

Project FS-R-4

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12 March 1996

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Abstract: Post-release survivorship and movement patterns were monitored for radiocollared raccoons (*Procyon lotor*) that were trapped as nuisance wildlife and translocated to a rural forest preserve (Translocated Urban), trapped in one forest preserve and translocated to another (Translocated Rural), and trapped in the forest preserve which served as the release site for the translocations (Resident). Thirty-one raccoons were radiotracked in autumn 1993, and 45 were radiotracked in autumn 1994. Survivorship was similar in all three treatment groups. Resident raccoons tended to remain in the vicinity of the release site, whereas Translocated raccoons left the release site within hours to days and dispersed into the surrounding area. Dispersing Translocated Urban or Translocated Rural raccoons had high daily movement rates for the first two weeks post-release, but then tended to settle down into new home ranges and showed daily movement rates similar to those of the Resident sample. Translocated raccoons denned near human residences and in agricultural fields more than did Resident raccoons. Raccoons in all three treatment groups had similarly high levels of intestinal parasites and positive tests for exposure to wildlife diseases (canine distemper virus, Leptospira interrogans, and Toxoplasma gondii). Although survivorship of translocated animals was high in this study, large numbers of translocations could cause problems for other wildlife and human residents near release sites, and translocated animals could serve as vectors for wildlife diseases during zoonotic outbreaks.

Key words: animal pest control, Illinois, nuisance wildlife, raccoon, survivorship, translocation

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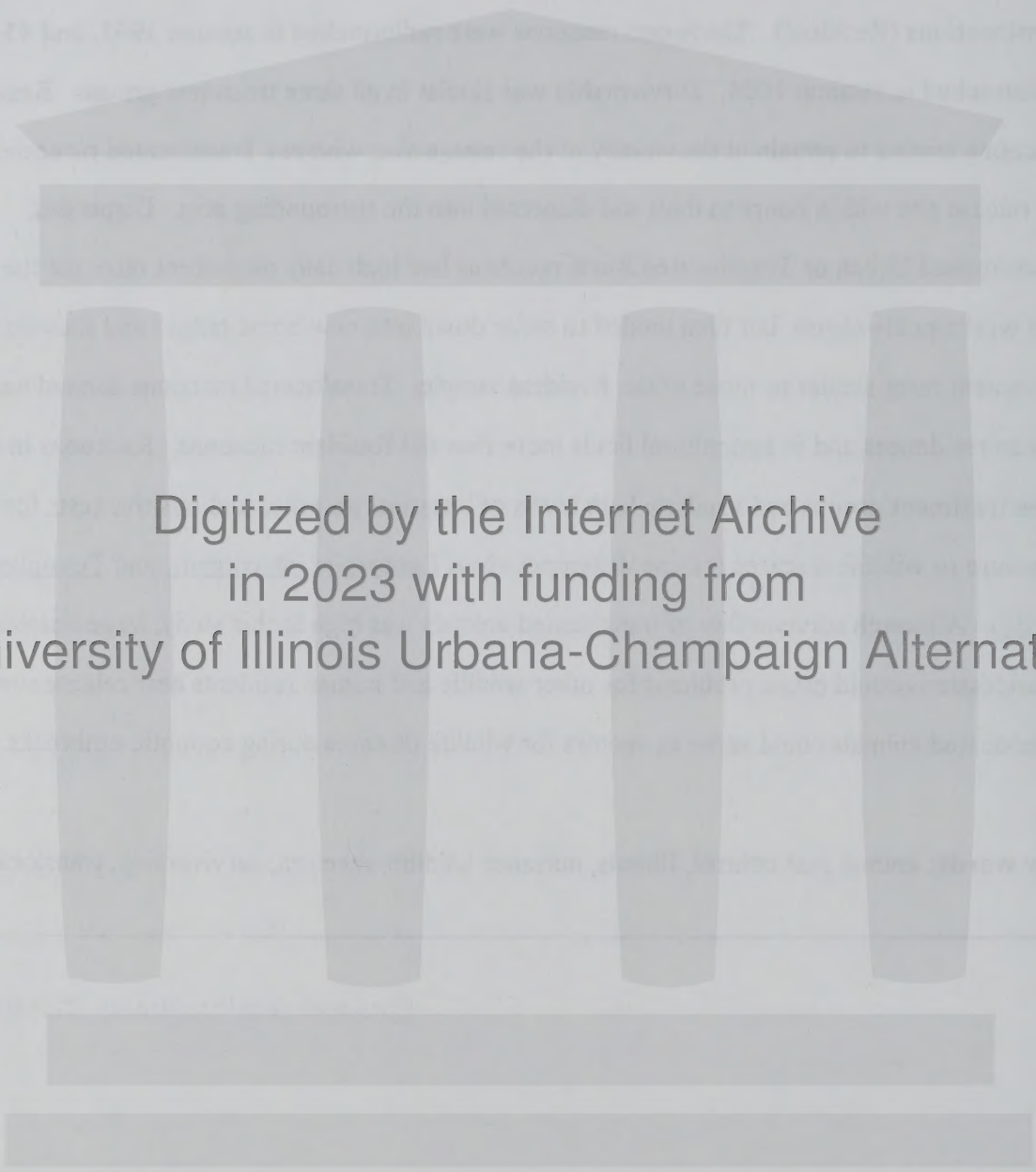

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In spite of the focus on threatened or endangered species in much of the literature on conservation biology, many species of wildlife are thriving in human-dominated landscapes. In the midwestern U. S., for example, some species of game and furbearing mammals such as white-tailed deer (Odocoileus virginianus), coyotes (Canis latrans), raccoons (Procyon lotor), and opossums (Didelphis virginiana) are probably near historical record high numbers (Hoffmeister 1989). As populations of humans also continue to increase, conflicts between humans and wildlife become inevitable. In 1994, for example, 45,331 mammals were handled by nuisance wildlife control permitees in the state of Illinois (Bluett 1995). Raccoons accounted for 13,193 of these mammals, and were by far the most common species handled. Many animals captured by animal control agents are euthanized, but many are released into woodlots or forest preserves in rural areas. A total of 18,879 mammals were reported as translocated and released in Illinois in 1994, including 5,832 raccoons (Bluett 1995). These numbers are typical of recent years, and probably underestimate the true numbers of translocated animals as many residents of rural areas often handle nuisance wildlife problems without reporting them to state agencies.

Translocating nuisance wildlife from urban or suburban areas to rural habitats appears on the surface to be a logical and humane way to handle problem animals. It is not clear, however, how well translocated animals survive after release. Studies of translocated deer, for example, have generally reported high mortality rates (O'Bryan and McCullough 1985; Jones and Witham 1990; Bryant and Ishmael 1991). Radiotelemetry studies of translocated raccoons have yielded mixed results. Frampton and Webb (1973) and Taylor and Pelton (1979) reported high survivorship among translocated raccoons, but Wright (1977) and Rosatte and MacInnes (1989) found that more than half of the raccoons translocated in their studies died within a few months of release. Further, few studies have evaluated the success of translocations from urban to rural environments (Rosatte and MacInnes 1989), and no published studies have simultaneously monitored survivorship in control populations of rural residents.

Translocating wildlife could facilitate the spread of zoonotic diseases (Davidson and Nettles 1992). For example, the rapid spread of rabies in raccoons in the eastern states of the U. S. has been linked to translocation of disease-carrying animals (Nettles et al. 1979; Smith et al. 1984; Jenkins et al. 1987). If translocated raccoons do not remain where they are released and migrate toward human residences, they could add to the nuisance wildlife problems in rural areas. Finally, translocated raccoons could increase competition for food or other resources for resident populations, disrupt existing social structure, or increase rates of predation on songbird nests or other threatened wildlife.

In this study, we compared survivorship, patterns of daily movement, dispersal away from the release area, and causes of mortality among raccoons translocated from an urban to a rural area, translocated from a rural to a rural area, and captured at the rural release site. In addition, blood from all three treatment groups were assayed for positive exposure to canine distemper virus (CDV), leptospirosis (Leptospira interrogans), and toxoplasmosis (Toxoplasma gondii), and fecal samples were examined for the presence of intestinal parasites (e.g., Baylisascaris), to determine if urban-dwelling raccoons were more likely to carry pathogens than rural-dwelling raccoons. A high incidence of pathogens in raccoons, particularly in urban-dwellers, would indicate a high risk of transporting potential zoonotic diseases into new areas when translocating animals. Finally, we recorded habitats used as daily den sites by translocated and resident raccoons as a coarse indicator of whether translocated raccoons were likely to add to wildlife nuisance problems for human residents of rural areas.

Support for this project was provided by the Furbearer Fund of the Illinois Department of Natural Resources, the Max McGraw Wildlife Foundation, the Illinois Natural History Survey, and the Kane County Forest Preserve District. Dr. E. Heske and Dr. J. Thompson gave advice and support throughout all phases of the research. Dr. L. Hungerford, Department of Veterinary Pathobiology, University of Illinois at Urbana-Champaign, provided the analyses of pathogens, and Dr. J. Brawn assisted with statistical analyses. F. Burbrink, S. Nelson, and R. Stockman provided able field assistance, and B. Reiter of Critter Control provided the raccoons removed

from urban areas in response to nuisance wildlife complaints. The Kane County Forest Preserve District kindly gave permission to conduct the study in the Lone Grove Forest Preserve.

STUDY AREA

The study was conducted in and around the Lone Grove Forest Preserve (LGFP), Kane County, Illinois, USA (80° 33' 45" E, 41° 51' 3" N). The preserve includes ca. 33.3 ha of mature upland forest in two contiguous blocks on either side of a paved road, 2 ha of oldfield undergoing succession, and 12 ha of open, mesic grassland bissected by a small creek (47.3 ha, or 117 acres total). A paved parking area at the north end of the preserve served as the release site for all translocated raccoons.

The area surrounding LGFP is dominated by row crop agriculture, primarily corn and soybeans. Agricultural fields were occasionally dissected by creeks or drainage ditches. A few isolated woodlots were scattered throughout the region. Most woodlots were small (<10 ha) and appeared as islands in the agricultural matrix. The only other trees in this landscape were associated with farmsteads, residential areas, and occasionally along creeks.

METHODS

Trapping and tracking were conducted from 30 Aug - 15 Nov 1993 and 28 July - 12 Nov 1994. Three treatment groups were considered in each year: Resident raccoons were live-trapped in LGFP, Translocated Urban raccoons were captured by licensed animal control agents in response to nuisance wildlife complaints, and Translocated Rural raccoons were live-trapped in a wooded forest preserve other than the release site (Max McGraw Wildlife Foundation, Dundee, Illinois).

All raccoons were trapped in box traps. Captured animals were lightly anaesthetized with Telazol, weighed, measured, and ear-tagged for individual identification. Approximately equal numbers of adult males and females in each treatment group were fitted with radiocollars (Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA). Radiocollars were equipped with a mortality switch and weighed 120–126 g. Blood samples were obtained from each radiocollared individual by cardiac puncture, and fecal samples were collected and preserved in 2.5% potassium

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dichromate solution. Animals were then monitored in their traps until they recovered from the anaesthetic, and released at LGFP. Translocated animals were released at a parking area on the north side of LGFP, and resident raccoons were released either at the parking area or at their capture site. Each raccoon was released within 24 hours of capture.

After release, radiocollared raccoons were located daily until mid–November. Azimuths were recorded using a vehicle-mounted, single-peak yagi antenna system. We attempted to record four azimuths per raccoon for each daily location from a set of fixed points corresponding to landscape features easily identifiable on maps and aerial photographs. Daily locations of radiocollared raccoons were then hand-plotted onto aerial photos. Data recorded for each location included linear distance from the release point, the straight line distance from the previous day's location, and habitat (woodlot, waterway, hedgerow, agricultural field, or residential property). Monthly checks from December through April in each year monitored survivorship through the winter. Aerial searches were used to supplement searches by ground vehicle (one in 1993, four in 1994).

Post–release survivorship curves were plotted for each treatment group using the Kaplan–Meier method (Pollock et al. 1989), and differences among treatment groups were compared using log rank tests. All analyses of survivorship data were conducted using the Advanced Statistics package in SPSS for Windows, Release 6.0 (SPSS 1993). When the mortality switch was activated in a radiocollar, we located the dead raccoon (or sometimes just the radiocollar) and attempted to determine the cause of mortality. To determine if overwinter survivorship was similar in the three treatment groups, the numbers of radiocollared raccoons in each group that died or survived between November and April were compared in each year using contingency tables and chi-squared statistics.

Dispersal was examined in three ways. First, the numbers of raccoons in each treatment group that remained near (<1 km from) the release site were compared. "Survivorship" curves were plotted to show the proportion of the original sample denning near the LGFP over time, and the numbers in each treatment group still denning < 1 km from the release site at 60 days post

release were compared using chi-squared statistics. Second, mean daily movement rates (linear distance between locations on successive days) for individuals in each treatment group were compared. Because some radiocollared raccoons could not be located each day, we calculated mean daily movement rates for each individual separately based on the data available for that individual blocked in two-week intervals. Thus, each individual contributed a single value to the group mean for that interval rather than a variable number of daily values. Differences in mean daily movement rates (blocked in two-week intervals) among treatment groups were then evaluated by repeated measures analysis of variance (rmANOVA), using treatment group as the main effect and mean daily movement rate blocked by two-week interval as the repeated measure. Statistical analyses were conducted using the Unbalanced Repeated Measures Models With Structured Covariance Matrices program in BMDP5V (BMDP 1992). Third, the mean linear distances from the release site for individuals that survived to the last two weeks of tracking in each treatment group in each year were compared. Individuals that disappeared from the study area and could no longer be located were considered to have dispersed >8 km, which is a conservative value given that vehicle searches typically covered an area around the release site with a radius much wider than this. Individuals known to have died before the last two weeks of tracking were not included in the statistical analysis. Differences among treatment groups were evaluated using Kruskall-Wallis tests because variances were not equal among groups even after various tranformations of the raw data. When significant differences among treatment groups were detected, pairwise comparisons between groups were conducted using Mann-Whitney U-tests (SPSS 1993).

Daily den locations were classified as occurring in one of five general habitat types: wooded areas, hedgerows, creeks or ditches, crop fields, or residential areas (farmsteads and other human habitations). Habitat use at this scale was easily determined in the field given the open landscape and grid-like system of rural roads. Because some individuals, particularly the Resident raccoons, were located more consistently than others, we quantified habitat use as frequency distributions for comparative purposes. A frequency distribution of den sites in each

habitat was first calculated for each individual. Frequencies in each habitat type were then summed over all individuals in each treatment group for each year, and overall frequency distributions were recalculated from these summed values. Thus, each individual contributed equally to the final frequency distribution for each treatment group in each year.

Analysis of blood and fecal samples was conducted by Dr. Laura Hungerford, Department of Veterinary Medicine, University of Illinois Urbana-Champaign. Details of this analysis will be reported elsewhere (Hungerford et al., in prep.), and results will only be summarized here as numbers of raccoons testing positive for exposure to each pathogen or genera of intestinal parasites observed in fecal samples.

RESULTS

Seventy–six raccoons were collared and radiotracked: 31 (15 males, 16 females) in 1993 and 45 (23 males, 22 females) in 1994. In each year, the sample of Resident raccoons was trapped and radiocollared before any raccoons in the Translocated samples were captured and relocated so that live-trapping would not be concurrent with releases at LGFP. Sample size in each treatment group was equal within each year, with the exception that 11 raccoons were radiocollared in the Tranlocated Rural group in 1993 (instead of 10). Radiocollared animals were monitored for a maximum of 77 days in 1993 and 107 days in 1994. All data are analyzed as days post-release, as release dates were staggered over a 32-day period in 1993 (30 Aug - 1 Oct) and 57 days in 1994 (28 July - 23 Sept). This staggering of release dates was due to the variable amount of time required to capture equal numbers of adult male and female raccoons for each treatment group, sequentially trapping first at LGFP and then at the source of the Translocated Rural sample, and waiting for suitable animals for the Tranloscated Urban sample to be captured in response to nuisance wildlife complaints.

Survivorship did not differ significantly between males and females in either year (Log rank statistic = 0.75, d.f. = 1, P = 0.39 in 1993; Log rank statistic = 1.38, d.f. = 1, P = 0.24 in 1994), so sexes were pooled for further analysis. Although survivorship curves appeared similar

between years, we analyzed each year separately because radiotracking was conducted for over a month longer in 1994 than in 1993.

Survivorship was high and did not differ significantly among the three treatment groups (Log rank statistic = 0.18, d.f. = 2, P = 0.91 in 1993; Log rank statistic = 0.66, d.f. = 2, P = 0.72 in 1994; Fig. 1). There were 14 known deaths recorded during the radiotracking periods in 1993 and 1994: five raccoons were roadkilled, four were considered poached (three collars were found discarded and one raccoon was found shot), one raccoon was trapped and killed as nuisance wildlife on private property, and four died of unknown causes (death occurred up in tree cavities or in ground burrows and carcasses were not recovered for necropsy). Known deaths were distributed similarly among all three treatment groups. In addition, 10 radiocollared animals could not be found by land or aerial searches after some point during the tracking periods, and their fates are unknown: two Translocated Rural and three Translocated Urban raccoons in 1993, and four Translocated Rural and one Translocated Urban raccoons in 1994. These "lost" raccoons were treated as censored data in the survivorship analyses, and we assume that they dispersed beyond the study area. Alternatively, their transmitters may have failed, but it is imporbable that all 10 failures should occur in the Translocated groups and none in the Resident group. Lost raccoons might have been resting in places such as culverts or barns where their signals were blocked, but it seems unlikely that such individuals could remain undetected by daily searches for periods of over a month in some cases. Finally, some of the lost raccoons could have been poached or killed as nuisance wildlife and their collars discarded in places such as trash cans where the mortality signals would not be detected.

Of 20 radiocollared raccoons known to be alive at the end of the tracking period in 1993, 14 survived the winter, four died between November and April, and two disappeared (fates unknown). Of 32 radiocollared raccoons known to be alive at the end of the tracking period in 1994, 23 survived the winter, four died between November and April, and five disappeared (Table 1). Pooling data from both years, the numbers that survived the winter, died during the winter, or were lost during the winter were not significantly different among treatment groups ($\underline{X}^2 = 3.86$,

d.f. = 4, $\underline{P}$ = 0.43). Excluding lost animals from the analysis did not affect the results ($\underline{X}^2$ = 2.17, d.f. = 2, $\underline{P}$ = 0.34).

Resident raccoons tended to den in or near LGFP during the radiotracking periods in both years with the exception of one male in 1993 and one female in 1994 (the latter wandered widely but returned periodically until killed on the road about one month post-release). In contrast, almost all Translocated raccoons dispersed from the release site (Fig. 2). In 1993, only two of 21 translocated raccoons were still denning within 1 km of the release site at LGFP at the end of the tracking period, and most had left the immediate area within 1-2 days post-release. In 1994, only three of 30 translocated raccoons were still denning within 1 km of the release site at LGFP at the end of the tracking period. Problems with our receiver began just at the time translocations were occurring in 1994, and we had increasing difficulty locating dispersing raccoons over a period of several weeks until the problem was identified and fixed. Resident raccoons and a few translocated raccoons were located regularly in and around LGFP during this interval, but because failure to locate a translocated raccoon in LGFP may have been due to technical problems as well as dispersal, we omit these data from Fig. 2. The small number of translocated raccoons detected in LGFP during this interval, however, suggests that the pattern in 1994 was similar to that in 1993. Pooling data from both years and excluding animals that died or were lost from consideration, 18 of 20 remaining Resident raccoons, three of 16 remaining Translocated Rural raccoons, and two of 17 remaining Translocated Urban raccoons were still denning within 1 km of LGFP at 60 d post-release; this difference is statistically significant ($\underline{X}^2$ = 28.57, d.f. = 2, $\underline{P}$ < 0.001). Differences in philopatry among the treatment groups is underestimated by this analysis because four of the raccoons in the Resident sample that died before 60 d post-release had consistently denned in the LGFP during the period that they were monitored prior to their deaths, and most of the "lost" raccoons in the Translocated samples had probably dispersed away from the preserve.

In 1993, the mean daily movement rates of Translocated raccoons was much greater than that of Resident raccoons during the first two weeks post-release (Fig. 3). Repeated measures

ANOVA did not detect significant variation between treatment groups ($\underline{X}^2 = 0.57$, d.f. = 2, $\underline{P} = 0.75$), probably because of the great variation among individuals (particularly in the Translocated groups). There was significant variation over time ($\underline{X}^2 = 45.14$, d.f. = 4, $\underline{P} < 0.001$), however, and a significant interaction term ($\underline{X}^2 = 22.94$, d.f. = 8, $\underline{P} = 0.003$) indicated that the pattern of variation over time was not equal among groups. This pattern was less clear in 1994, but the difference between years is likely an artifact of our difficulty in locating the more widely-ranging individuals due to problems with the receiver at this time. Statistical analysis of the 1994 data were not possible because of the large number of missing values during this early interval. Because sample sizes also were variable in later time intervals, and the most widely ranging individuals were often the ones that were lost or died, differences in mean daily movement rates among treatment groups are difficult to interpret. Mean daily movement rates typically decreased after 2-4 weeks among Translocated raccoons that were still being monitored, and many of these individuals appeared to have settled into new home ranges as indicated by repeated denning within a local area.

Whereas most of the Resident raccoons remained near the release site, many of the Translocated Rural and Translocated Urban raccoons dispersed considerable distances (Fig. 4). Translocated raccoons were located as far as 24, 25, and 60 km from the release site during aerial searches. The mean distance from the release site for radiocollared raccoons, excluding known mortalities, at the end of the period of tracking each year differed significantly among treatment groups (1993: $\underline{X}^2 = 7.78$, d.f. = 2, $P = 0.02$; 1994: $\underline{X}^2 = 18.95$, d.f. = 2, $\underline{P} < 0.001$). In both years, the mean distance from the release site for Resident raccoons was significantly less than that for both Translocated Rural and Translocated Urban raccoons (all $\underline{P} < 0.05$), whereas Translocated groups did not differ significantly in either year (all $\underline{P} > 0.05$).

The frequency with which different types of habitat were used for den sites differed among treatment groups (Fig. 5). Resident raccoons denned most frequently in wooded areas (i. e., LGFP). Translocated raccoons denned more frequently near human residences than did Resident raccoons, and often denned in agricultural fields and along waterways as well.

The incidence of canine parvovirus among the raccoons tested was high (95% overall), and similar among all three treatment groups. Only one raccoon tested negative for CPV in 1993, and three tested negative for CPV in 1994 (Table 2). Fifty-one percent of the raccoons tested for exposure to leptospirosis were positive, and 28% of the raccoons tested for exposure to toxoplasmosis were positive (Table 2). As with CPV, the distribution of positive test results was similar among raccoons in all three treatment groups. Sample sizes varied among groups tested due to variation in the total amount of blood drawn per animal, difficulties in drawing blood from the earliest samples in 1993 (initial attempts to draw venous blood from the hind leg had mixed success), and occasional failure to collect a sample.

Only eight out of 43 fecal samples (19%) from raccoons examined in our study did not contain ova of intestinal parasites. Thirty-three percent of the fecal samples examined contained ova of Baylisascaris spp., 35% contained ova of Capillaria spp., and 47% contained ova of Eimeria spp. (Table 3).

DISCUSSION

Translocation of nuisance wildlife is permitted in 47 of the U.S. states, 36 of which list the raccoon as their most commonly translocated species. Four states (Connecticut, Delaware, New Jersey, Utah) prohibit the translocation of raccoons, and while all 50 states allow animals to be euthanized, only three (Florida, Massachusetts, Pennsylvania) make euthanasia mandatory for the raccoon (Craven 1993). Whereas translocation is often considered the most humane method of handling nuisance wildlife by the general public (Diehl 1988), studies of the survivorship of translocated animals have yielded conflicting results (e.g., Frampton and Webb 1973; Wright 1977; Taylor and Pelton 1979; Rosatte and MacInnes 1989) and the impact of translocations on wildlife and humans living near the release sites often has not been considered.

In our study, survivorship was generally high among translocated raccoons, averaging about 80% at two months post-release (Fig. 1), and did not differ significantly from survivorship in a sample of raccoons trapped at the release site. Frampton and Webb (1973) suggested that translocations were most likely to be successful when population density at the release site was

low. Raccoons were abundant in the area around LGFP, however, as indicated by high trapping success when we were capturing animals for our Resident sample. All 15 adult raccoons radiocollared in 1994 were captured in LGFP in only five nights (14 traps per night); this number does not include an adult male and several juveniles that were released without radiocollars. In 1993, an attempt to identify resident raccoons using a mark-recapture protocol resulted in 48 raccoons being ear-tagged in LGFP over a 45-day period in Aug. - Sept. High survivorship of translocated raccoons in our study is probably attributable to benign weather conditions during the autumn, and abundant food and cover provided by ripening agricultural crops.

Because we did not recapture radiocollared raccoons, we do not have data on the physical condition of animals at the beginning of winter. Overwinter survivorship was similar, however, among all three treatment groups. Severe winter weather did not begin until about three months after translocations were conducted, and translocated raccoons still being monitored at the end of the autumn radiotracking period had typically located new home ranges and den sites by that time.

In contrast to survivorship, movement patterns differed considerably between Resident and Translocated raccoons. Most of the Resident sample remained in the vicinity of LGFP, and with few exceptions the linear distance between successive den sites averaged less than 400 m. Both Translocated Rural and Translocated Urban raccoons typically dispersed from the release site within hours to a few days. In 1993, the mean daily movement rate averaged about 1 km during the first two weeks post-release, with individual records as much as 5 km. After about two weeks post-release, mean daily movement rates by Translocated raccoons was similar to that of Resident raccoons, but this result may be slightly biased because Translocated raccoons that dispersed from our study area and were only relocated by aerial searches or were lost could have maintained high movement rates. In 1994, this difference in daily movement rates during the first two weeks post-release could not be demonstrated, but we had difficulty locating dispersing raccoons because of hardware problems. The probability that a translocated raccoon would remain at the release site, the pattern of daily movements, and the total distance dispersed from

the release site by the end of the tracking period did not differ between raccoons translocated from urban to rural or from rural to rural environments in any consistent way.

Because most of the translocated raccoons did not stay at the release site and sometimes dispersed considerable distances before settling down, it is possible that translocated animals could add to nuisance wildlife problems for rural human residents or increase the spread of disease during zoonotic outbreaks. Many of the translocated raccoons denned near human residences or on residential property, including backyards, barns, houses, and even a gas station. Two translocated raccoons were recaptured because of nuisance behavior (one during the tracking period and one during the winter of 1994). Raccoons also showed high incidences of exposure to various wildlife diseases, which indicates that the risk of translocating disease along with nuisance animals during periods of zoonotic outbreaks is correspondingly high.

It also is possible that the translocated raccoons could cause problems for the resident wildlife regardless of whether they remain at the release site. Raccoons have been implicated as important nest predators on songbirds (e.g., Whelan et al. 1994) and other wildlife (e.g., turtles: Christens and Bider 1987; Congdon et al. 1987). Translocated raccoons may compound the intense predation pressure already experienced by some wildlife in fragmented habitats. In some areas, exisitng management practices (e. g., waterfowl management: Llewellyn and Webster 1960; Urban 1970; Fritzell 1978) near a release site could be jeopardized by an infusion of translocated raccoons. Finally, increased competition for food and den sites could negatively affect resident raccoons. All of these areas deserve further study.

MANAGEMENT IMPLICATIONS

Relocation programs for nuisance wildlife sound simple and are generally appealing to the public (Diehl 1988). Studies of the survivorship of translocated raccoons have yielded mixed results, and the success of an individual translocation probably depends on a variety of factors including condition and health of the translocated animal, population density at the release site, area and quality of habitat at the release site, and time of year. This study shows that, at least in

some situations, survivorship among translocated animals can be as high as that among resident animals. Even when a translocated raccoon survives, however, it rarely stays at the release site. Dispersal could be a consequence of competition for den sites or other resources with resident animals at the release site, or due to disorientation and attempted homing on the part of the released animals.

The large number of animals translocated each year clearly could increase competition for resources with resident raccoons, predation pressure on other wildlife, and nuisance wildlife problems for human residents near release sites. Records from licensed animal controllers in Kane Co. show that at least 84 raccoons were released in LGFP in 1993 prior to our study, and 823 more were released at other sites within the county. Numbers of raccoons in most of the Midwest are high, and there is virtually no place to release a translocated raccoon where there is not already a substantial population of other raccoons or of people. Further, most nature preserves around urban or suburban areas are relatively small; there is no vast wilderness awaiting the thousands of animals handled by animal control professionals each year. When the risk of rapidly spreading disease during zoonotic outbreaks also is considered, translocation of nuisance wildlife becomes a less attractive option.

Alternatives to translocation of nuisance wildlife also have their drawbacks, however. The simplest alternative is euthanasia. Other means for controlling the population density of wildlife in urban or suburban areas, such as use of reproductive inhibitors (Howard 1967) or surgical sterilization (Bojrab 1986), are costly and labor intensive. Exclusion from private property (Hadidian et.al. 1991) would be the most humane solution, but may be difficult and ineffective. Thus, the negative effects of translocating large numbers of animals on wildlife and human residents of rural areas near release sites must be weighed against the ethical considerations of

euthanasia and negative public opinion when determining policy for the disposition of nuisance wildlife.

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Table 1. Overwinter (November to April) survivorship of radiocollared resident and translocated raccoons still being monitored at the end of the autumn radiotracking period in two years of study.

	1993			1994		
Treatment Group	Survived	Died	Disappeared	Survived	Died	Disappeared
Resident	5	1	1	11	1	
Translocated Rural	5	2	1	4	2	2
Translocated Urban	4	1		8	1	3

Table 2. Incidence of positive tests for exposure to three wildlife diseases in three treatment groups of raccoons. Number in parentheses indicates total number of raccoons tested. Treatment groups: R = Resident, TR = Translocated Rural, TU = Translocated Urban.

	Canine parvovirus			Leptospira interrogans			Toxoplasma gondii		
Year	R	TR	TU	R	TR	TU	R	TR	TU
1993	4(5)	9(9)	7(7)	1(2)	6(7)	2(5)	0(3)	92(7)	2(5)
1994	14(15)	10(10)	12(14)	7(13)	5(9)	2(9)	4(14)	4(9)	1(9)
Total	18(20)	19(19)	19(21)	8(15)	11(16)	4(14)	4(17)	6(16)	3(14)

Table 3. Incidence of intestinal parasites in three treatment groups of raccoons. Number in parentheses indicates total number of raccoons examined. Treatment groups: R = Resident, TR = Translocated Rural, TU = Translocated Urban.

	1993			1994		
Parasite	R	TR	TU	R	TR	TU
Baylisascaris	1(4)	4(8)	3(6)	3(8)	0(8)	3(9)
Capillaria	0(4)	4(8)	2(6)	2(8)	3(8)	4(9)
Eimeria	2(4)	5(8)	1(6)	7(8)	3(8)	2(9)
No ova seen	1(4)	1(8)	0(6)	0(8)	3(8)	3(9)

FIGURE LEGENDS

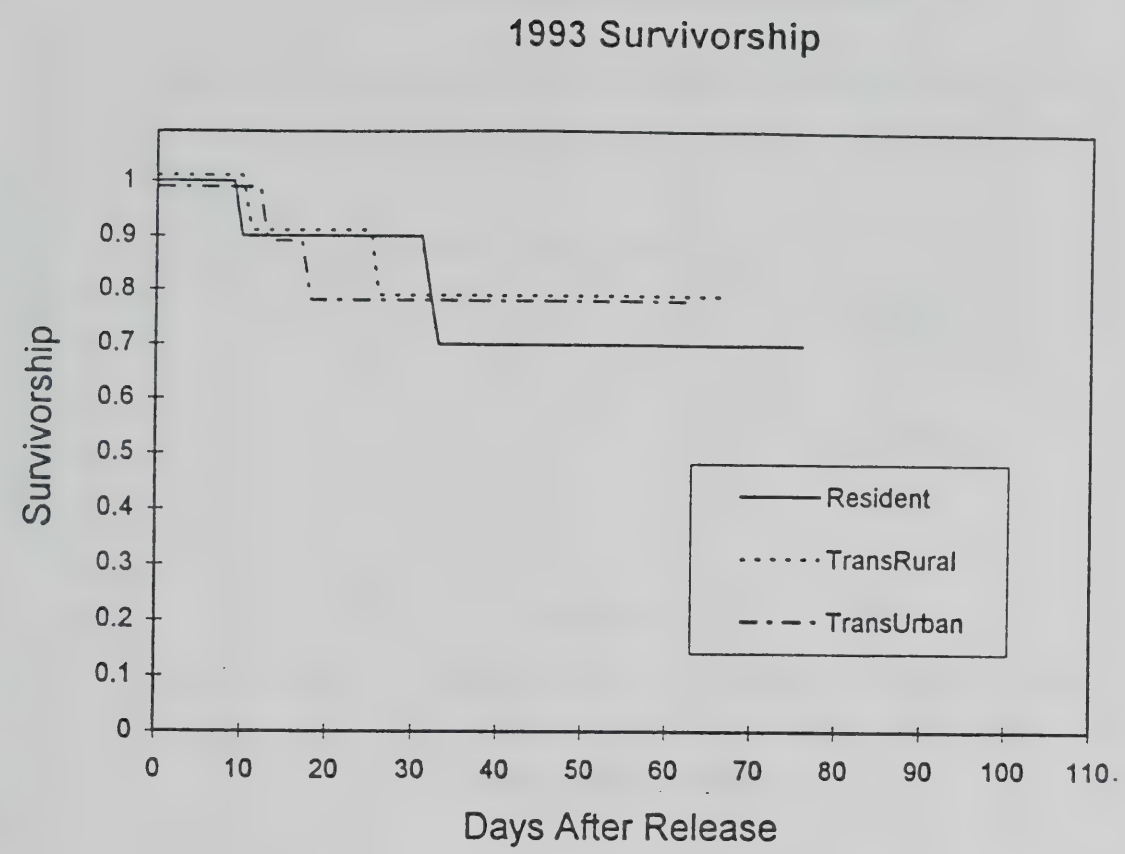
Fig. 1. Kaplan-Meier survivorship curves, measured in days post-release, for radiocollared raccoons in three treatment groups in two years of study.

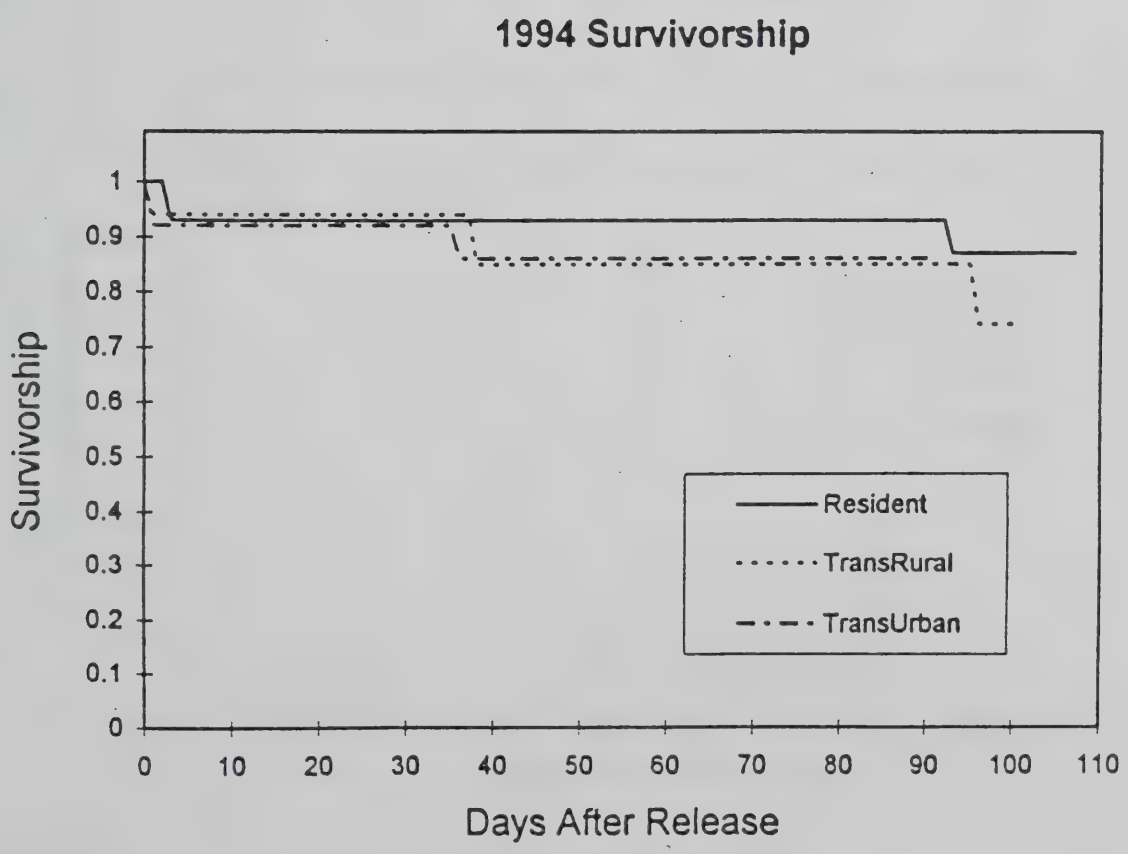
Fig. 2. Percent of the original number of radiocollared raccoons in three treatment groups denning < 1 km from the release site over time (days post-release) in two years of study. Question marks for Translocated Rural and Translocated Urban groups in 1994 indicate period when data are incomplete due to difficulties with the radio receiver.

Fig. 3. Mean distance between den sites on successive days, blocked by two-week intervals, for radiocollared raccoons in three treatment groups in two years of study. Numbers on tops of bars indicate numbers of individual raccoons contributing to the mean for each interval.

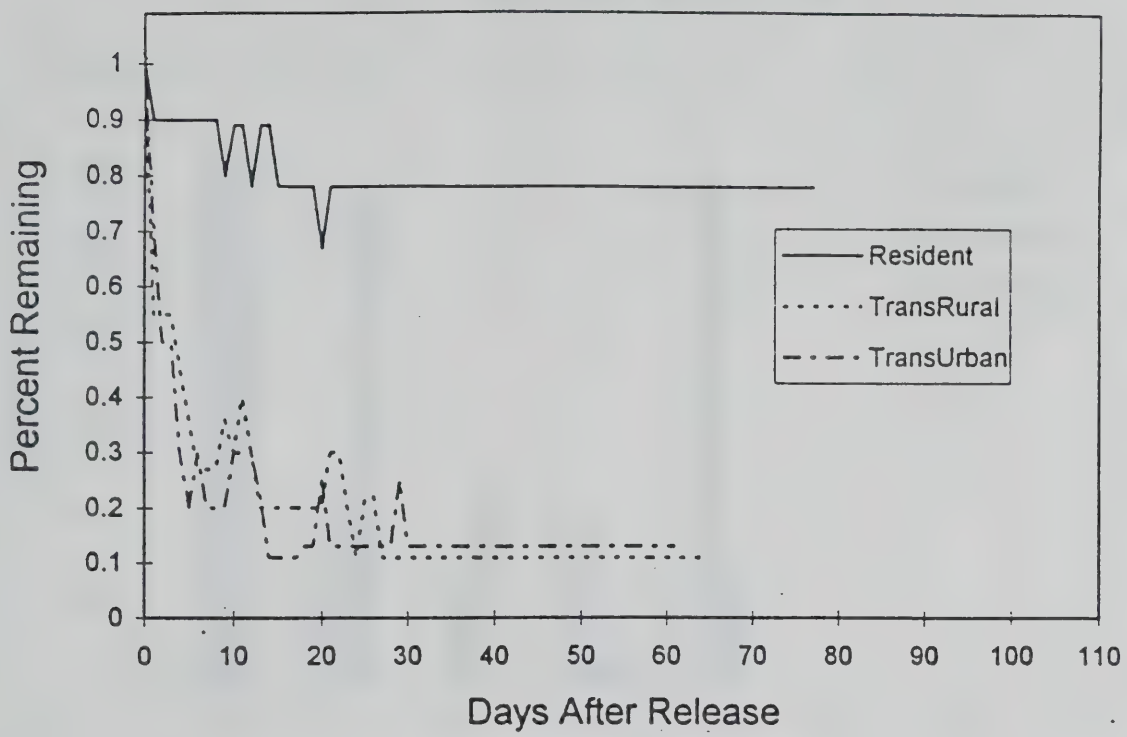
Fig. 4. Mean distance from the release site, blocked by two-week intervals, for radiocollared raccoons in three treatment groups in two years of study. Numbers on tops of bars indicate numbers of individual raccoons contributing to the mean for each interval. Final values indicate mean distances at the end of the period of radiotracking in each year.

Fig. 5. Frequency distributions of habitats selected for den sites by radiocollared raccoons in three treatment groups, weighted so that each individual raccoon contributes equally (see text), in two years of study.

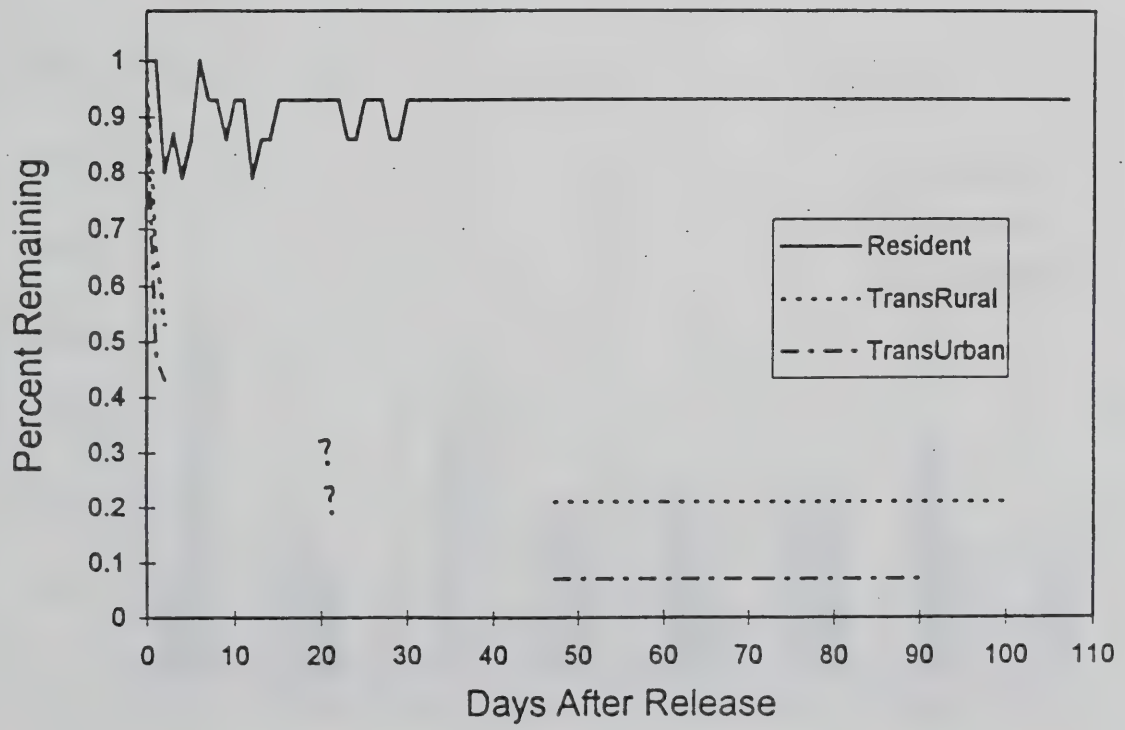

1993 Survivorship
Survivorship
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
110
Days After Release
Resident
TransRural
TransUrban


1994 Survivorship
Survivorship
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
110
Days After Release
Resident
TransRural
TransUrban

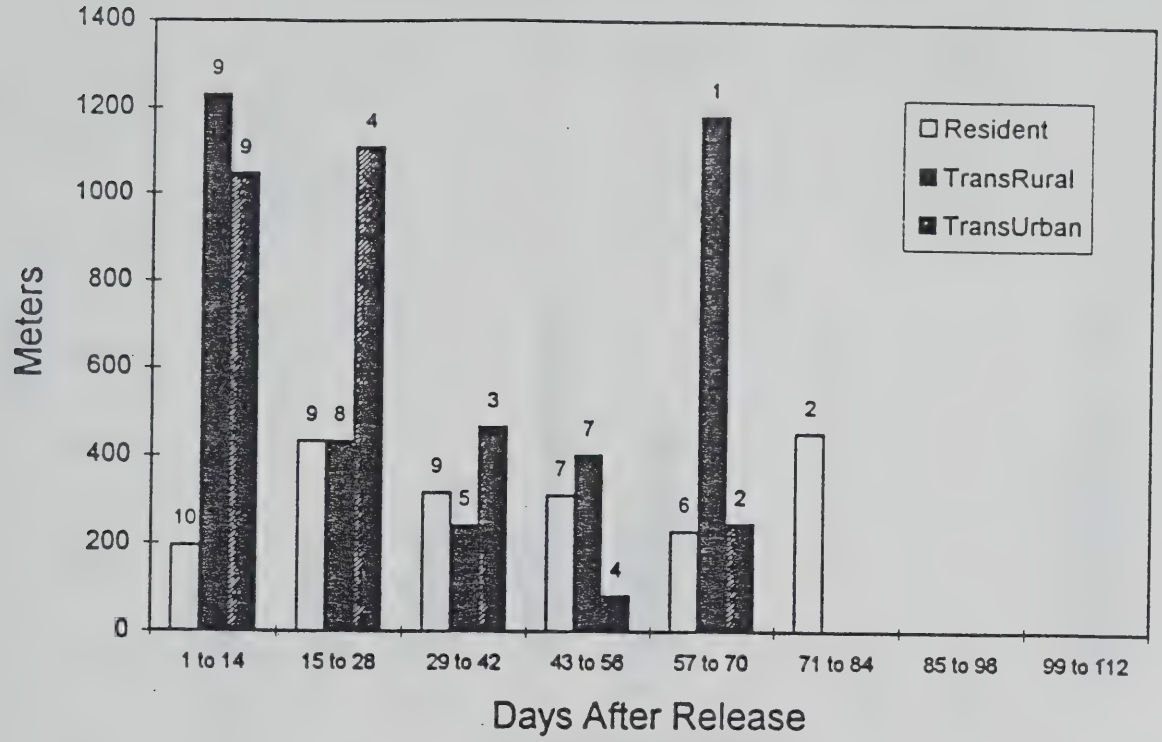
1993 Remain at Release Site



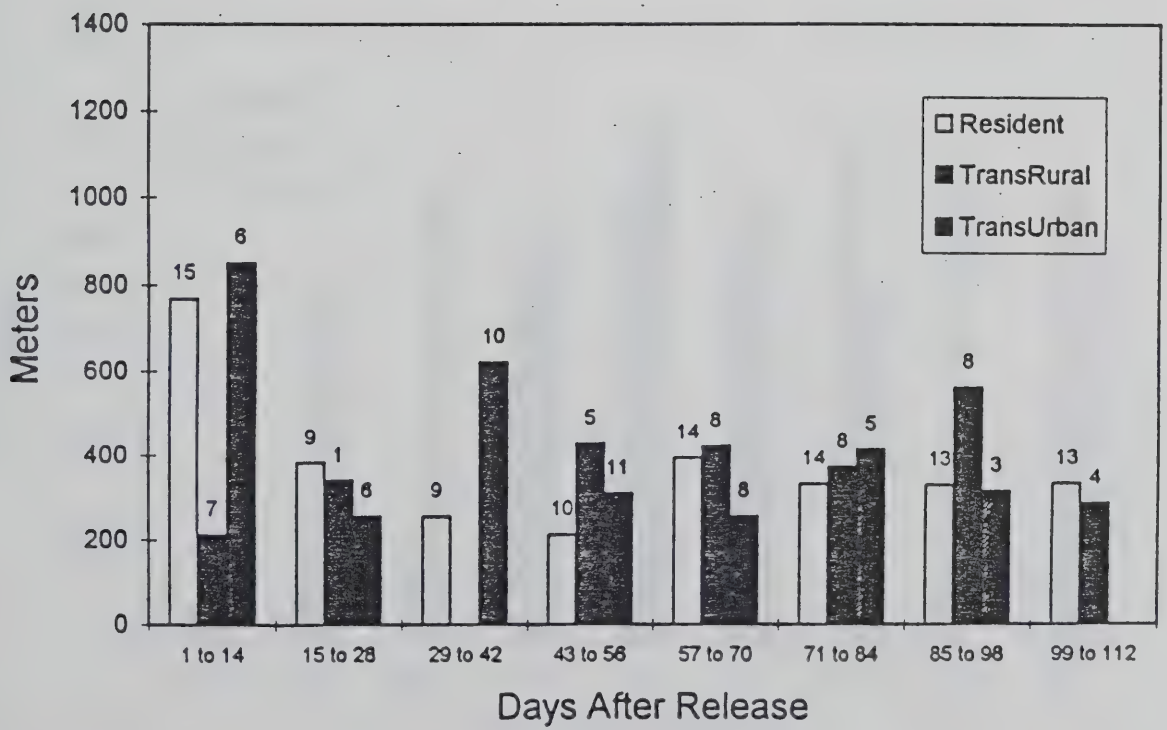
1994 Remain at Release Site

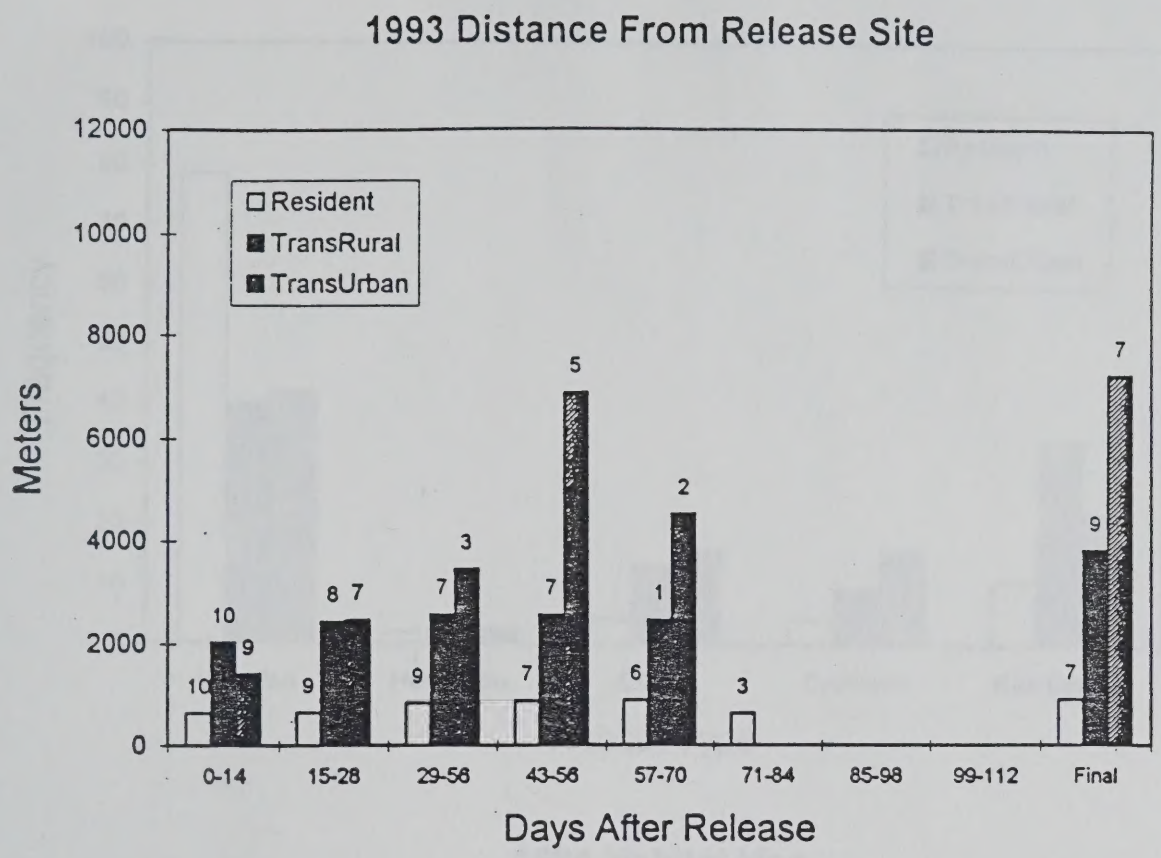


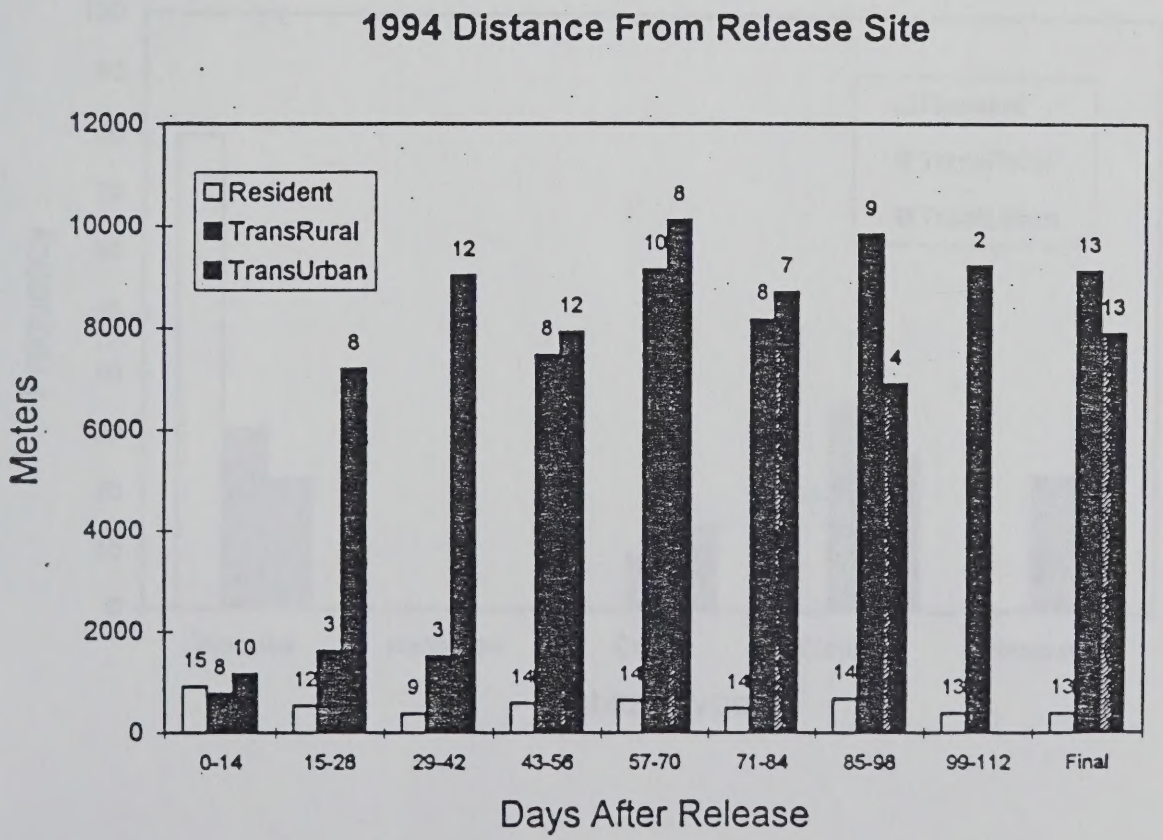
1993 Daily Movement



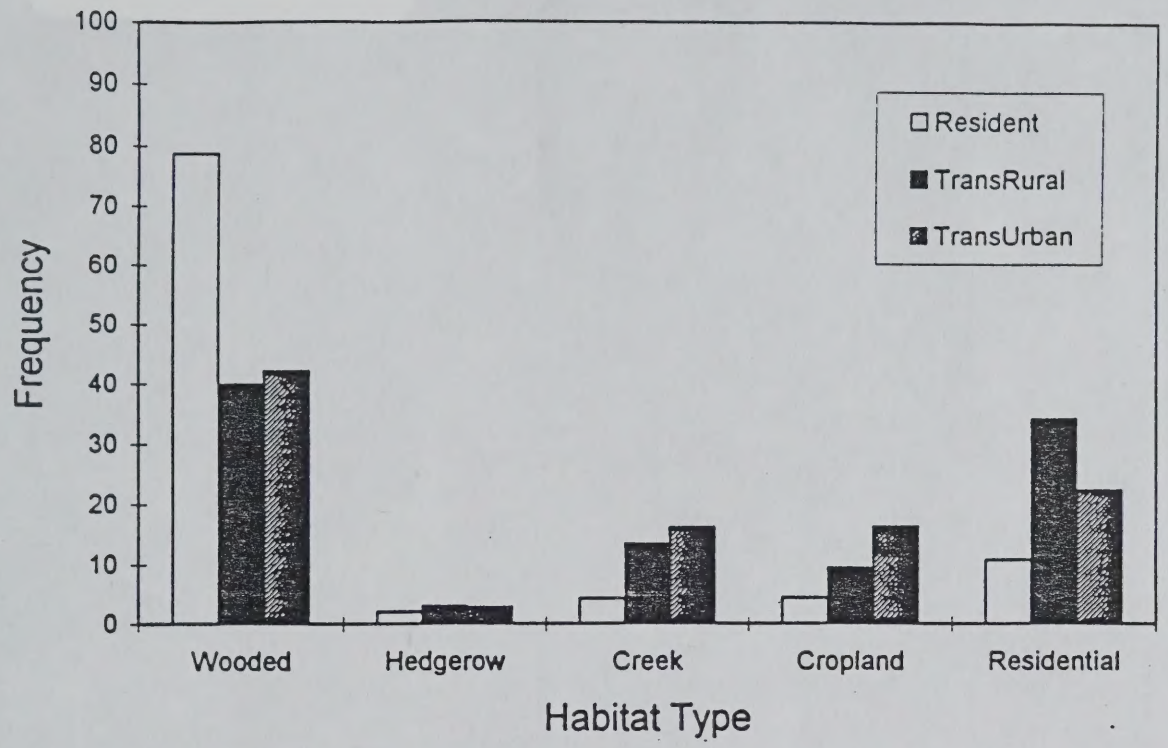
1994 Daily Movement



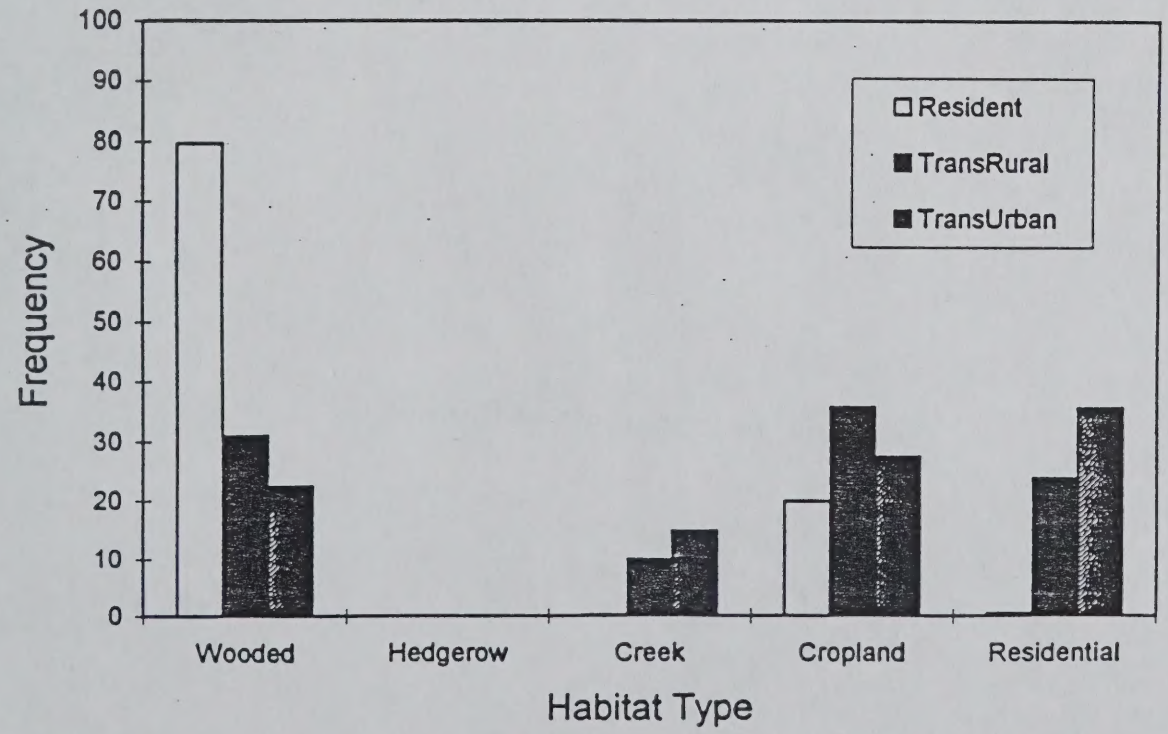

1993 Distance From Release Site
Resident
TransRural
TransUrban
Meters
12000
10000
8000
6000
4000
2000
0
0-14
15-28
29-56
43-56
57-70
71-84
85-98
99-112
Final
Days After Release


1994 Distance From Release Site
Resident
TransRural
TransUrban
Meters
12000
10000
8000
6000
4000
2000
0
0-14
15-28
29-42
43-56
57-70
71-84
85-98
99-112
Final
Days After Release

1993 Habitat Use



1994 Habitat Use



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